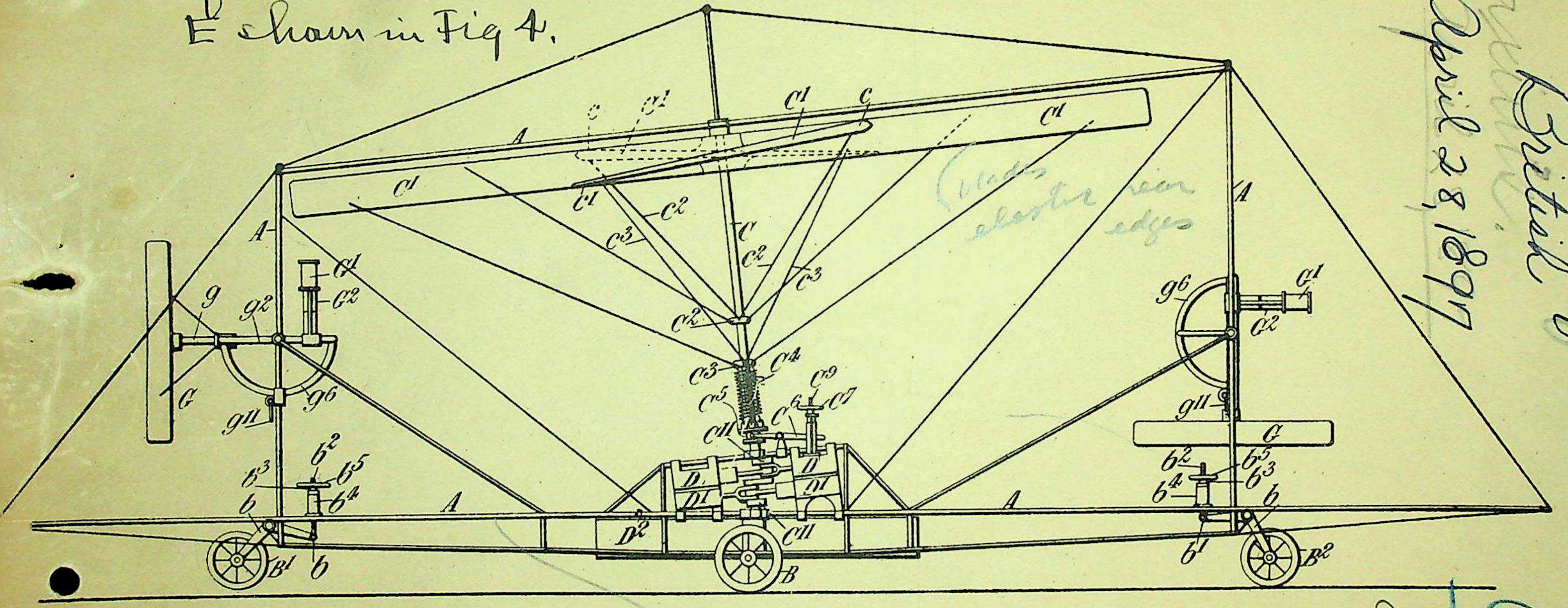
Throttle of engines which run propellers governed by pendulum, also by hand, pitch of blades varied, by hand. load shifted automatically to change inclination, propellers shifted thru 180°, engine shifted with propeller, tubular frame of machine used as Fig. 1. a condenser. Pendulum E shown in Fig 4.



blades elastic rear edges

106,208/1897 British

April 28, 1897

Br. Pt.

Machine

Print

Apr 28, 1897

May throttle shown if steam engines are used

See Br. pat. Latham 367,200

Br. pt. Maxim [illegible]

No 22

170-135.22

Fig. 2.

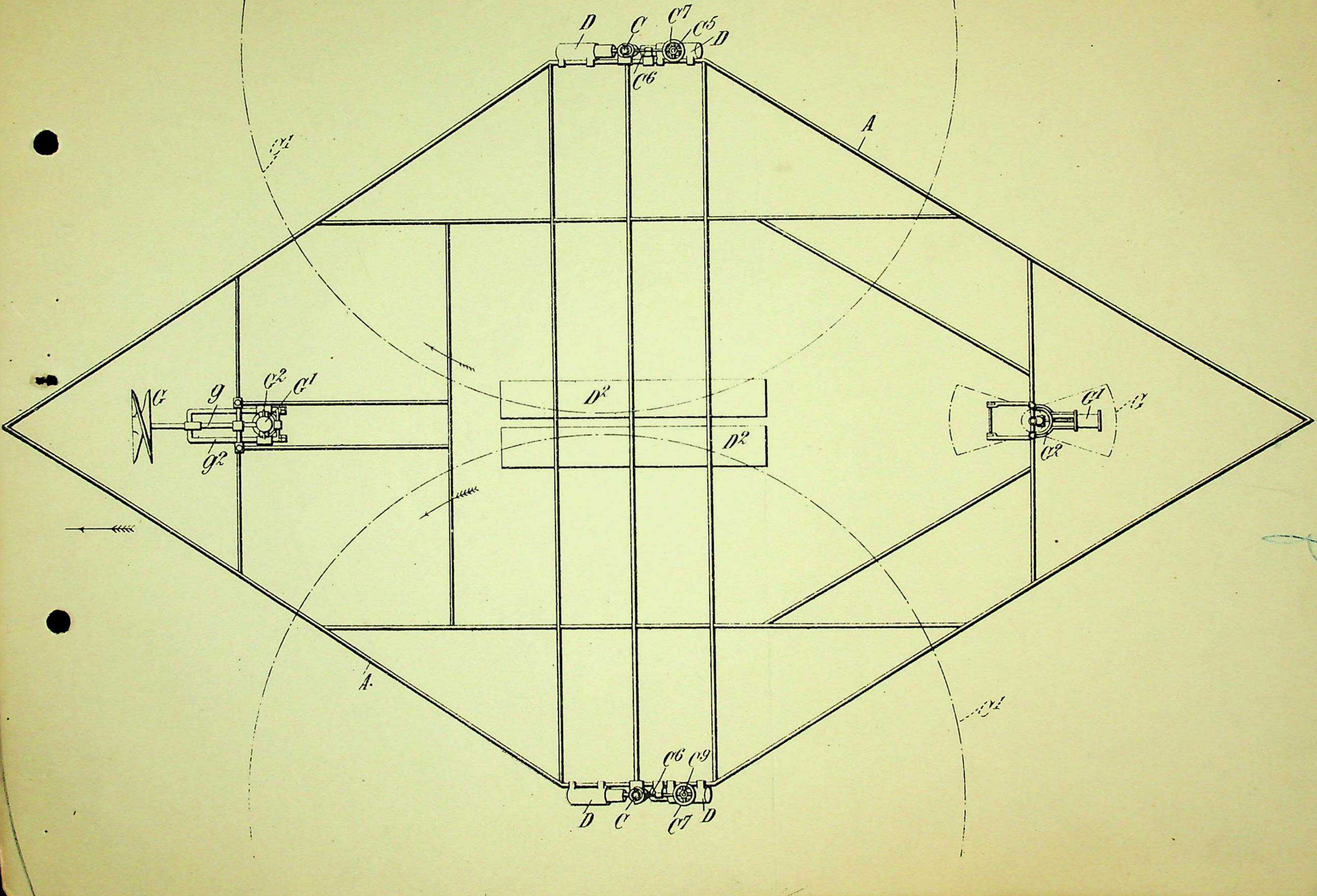


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Fig. 3.

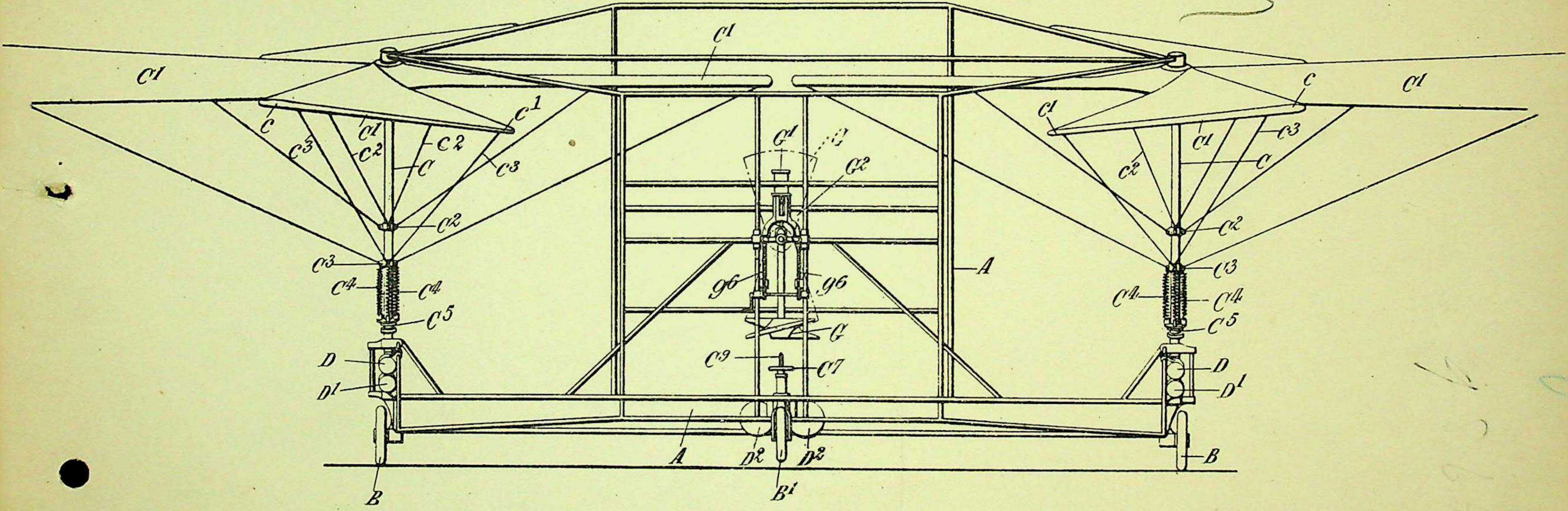

Fig. 4.

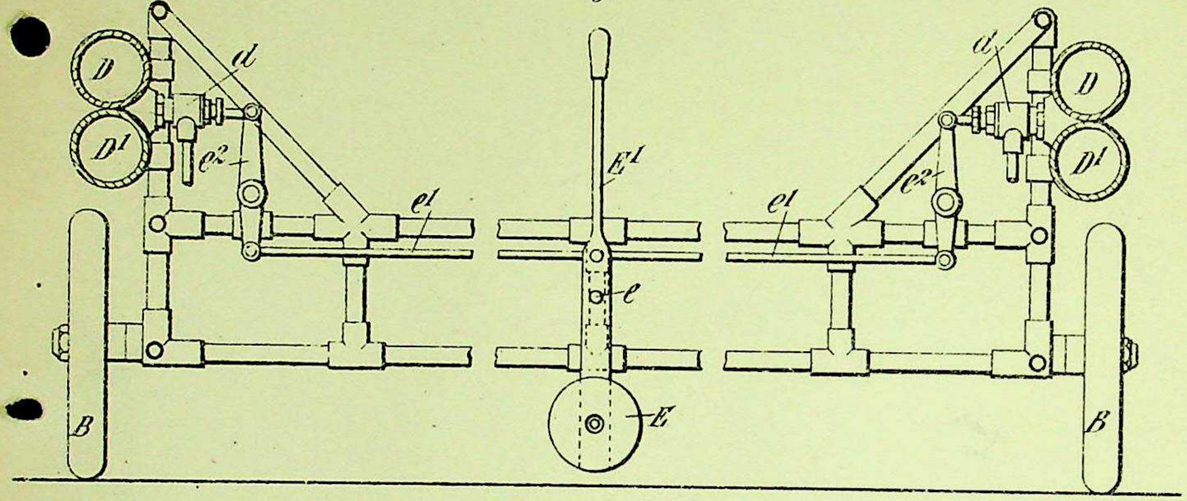

Fig. 5.

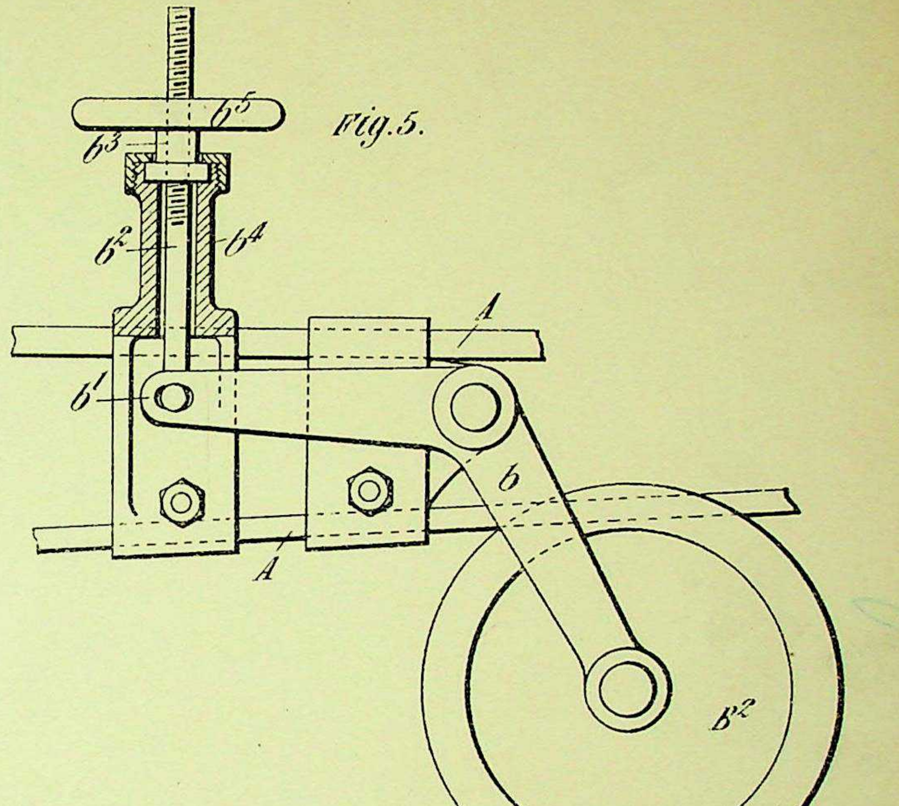

Fig. 6.

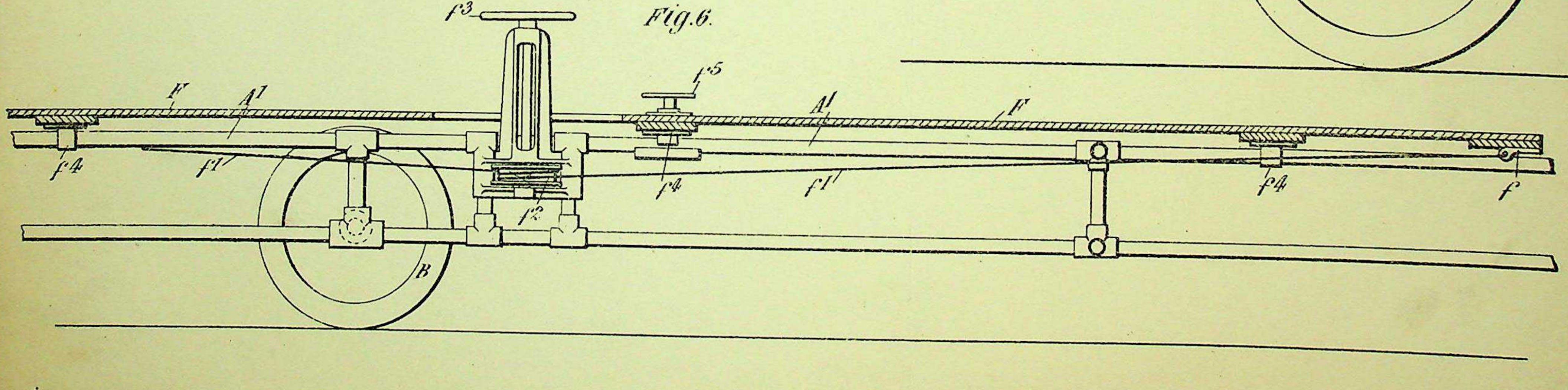

Fig. 7.

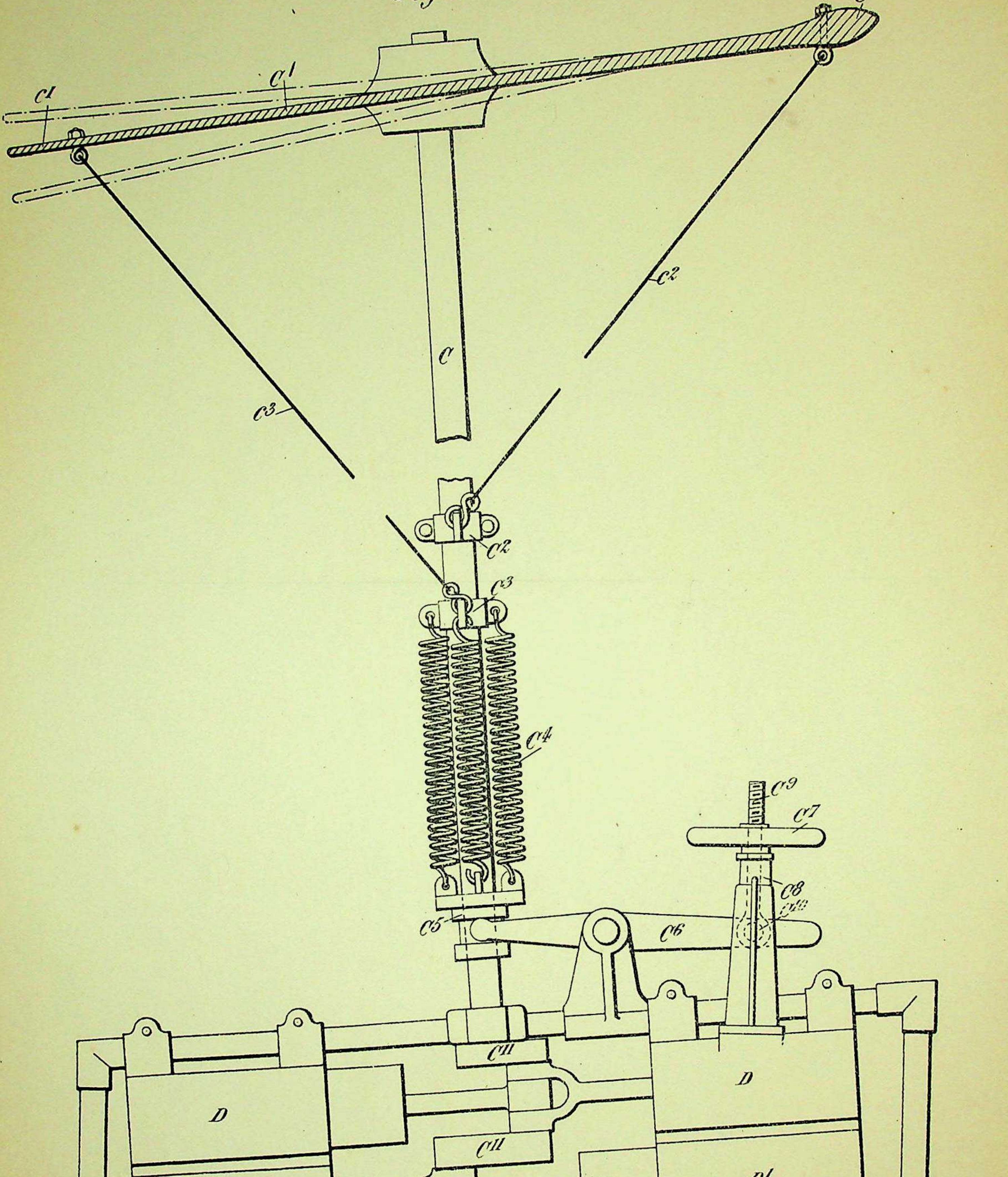

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Fig. 10.

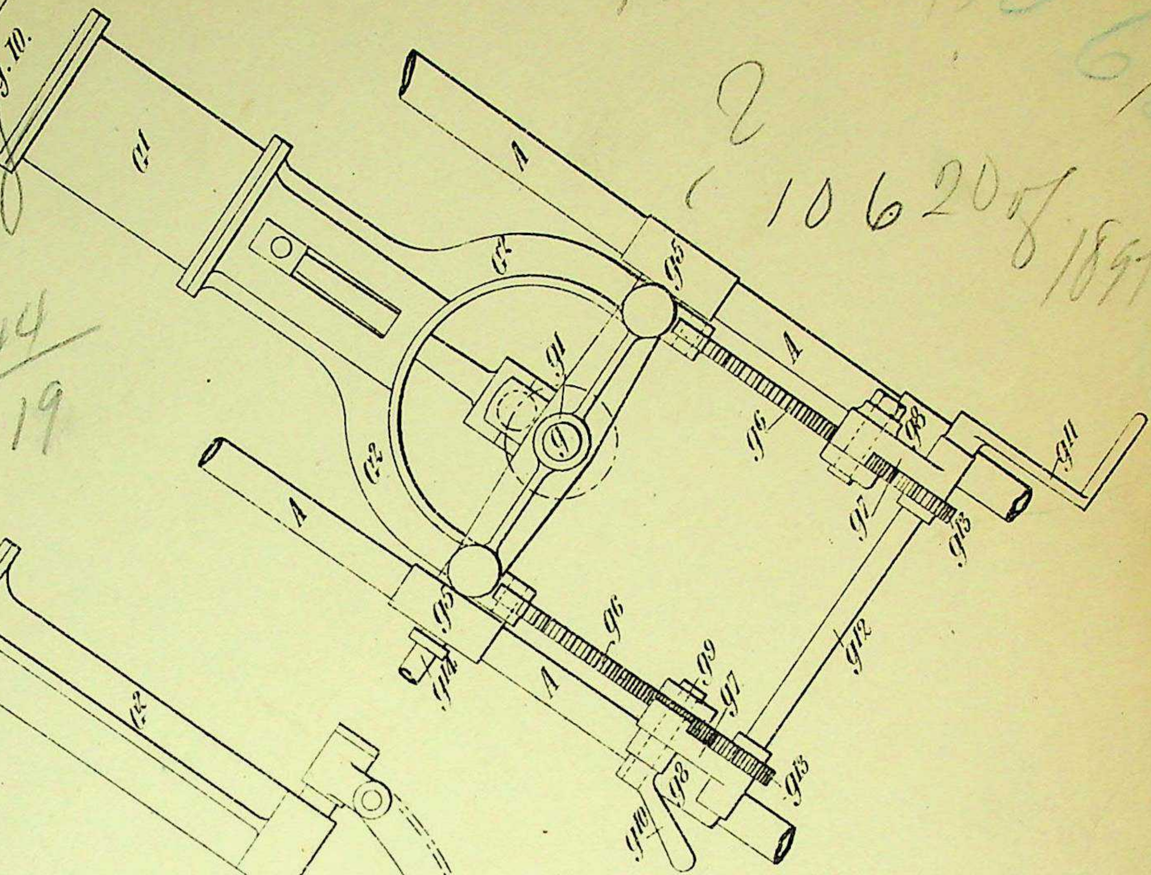


Fig. 8.

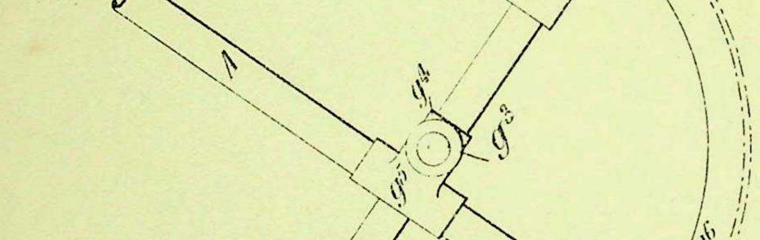
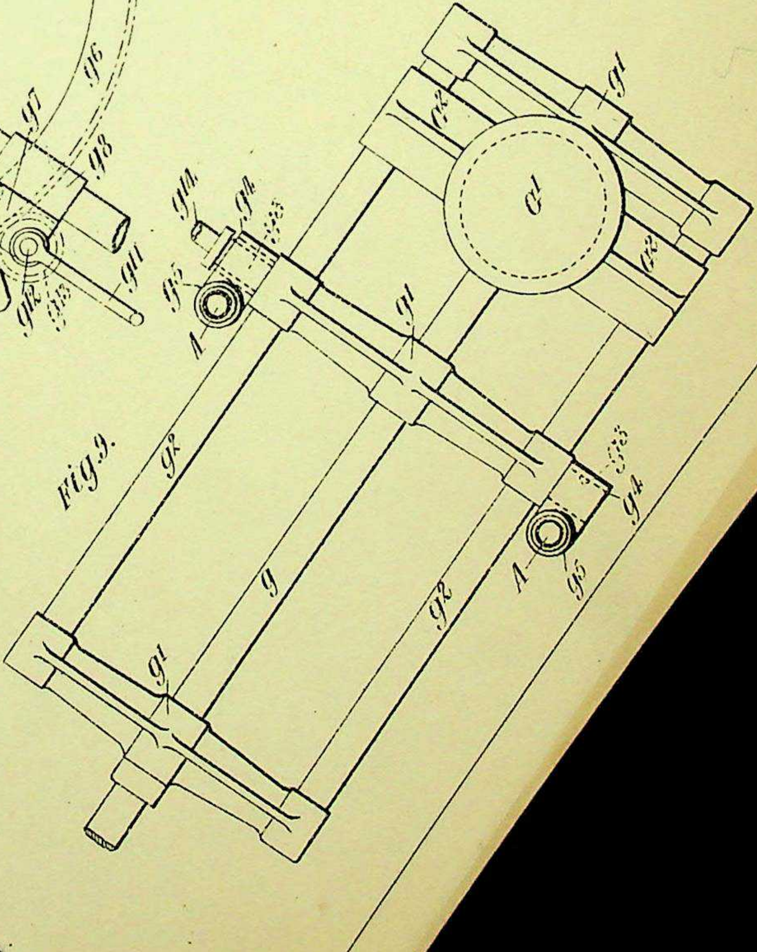


Fig. 9.



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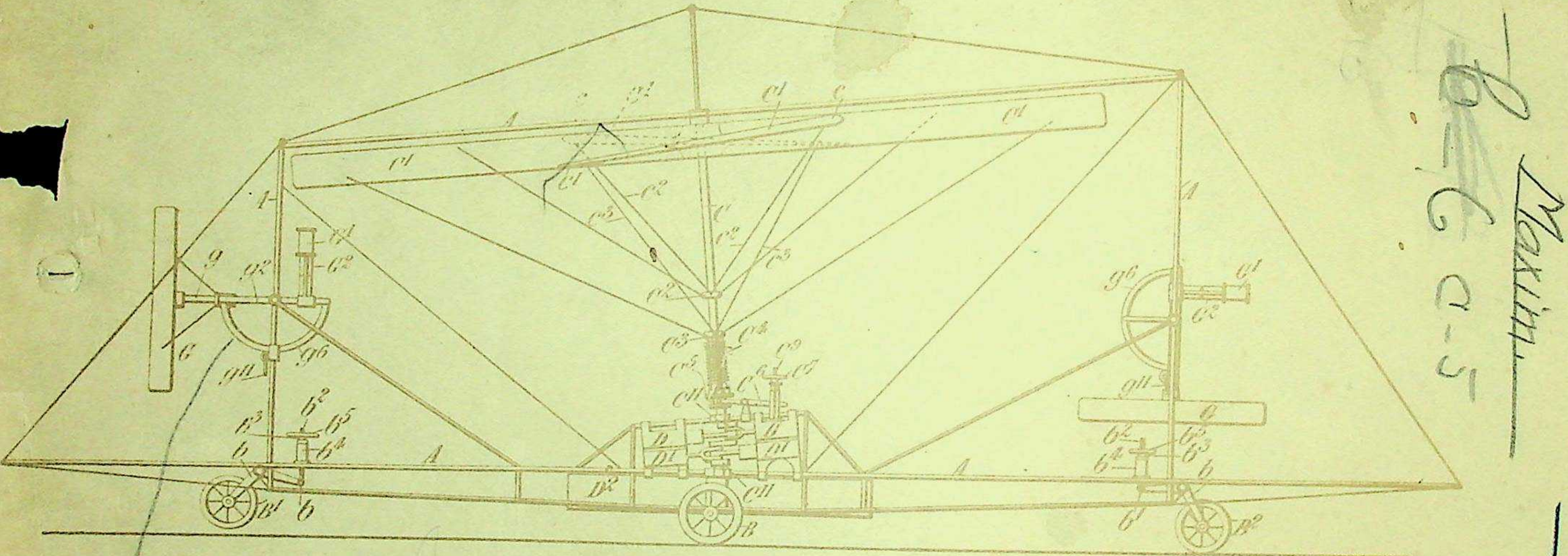
Pendulum operates air or gas valve of engine to work propeller blades for balancing.

Fig. 1.



Rack & pinion to shift Propeller

~~344-19~~ Div. 22

NEUMATICS,

[This Drawing is a reproduction of the Original on a reduced scale]

ial Navigation.

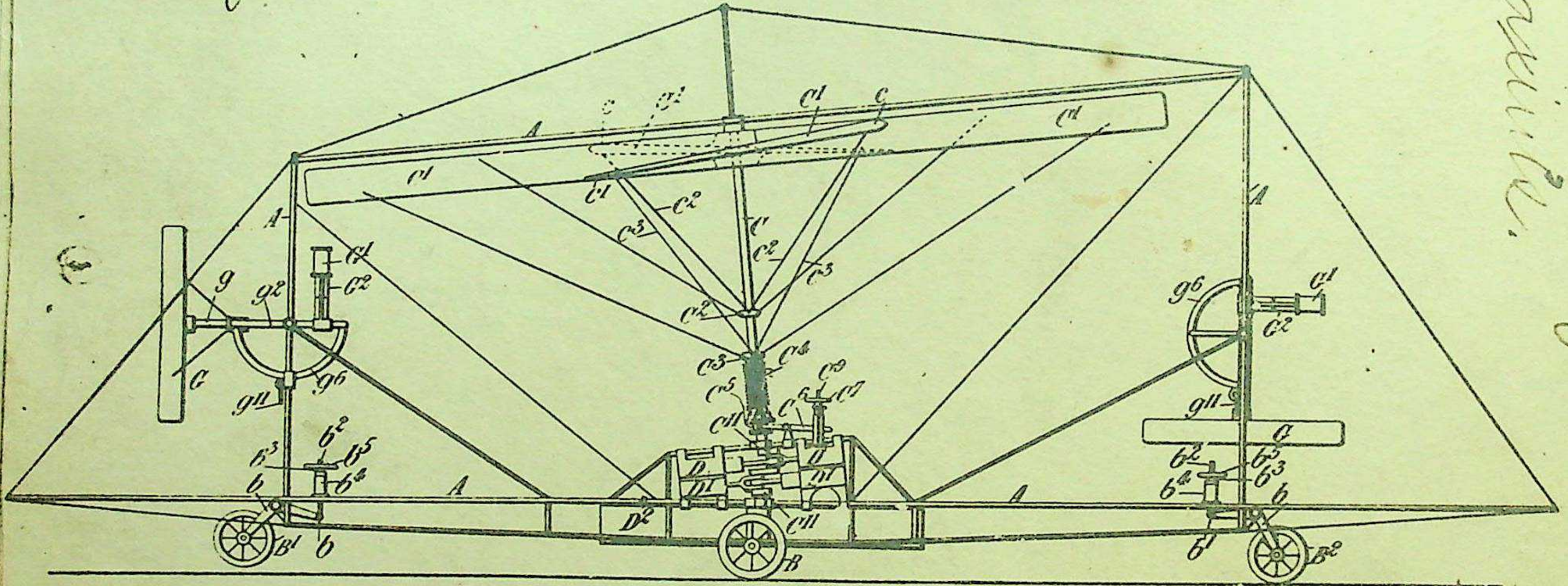
44/7.2 H-2 Br. Pt. 10.620 / '97

Maxim.

~~6~~ - 6 c-5

Throttle of engines which run propellers governed by pendulum, pitch of blades varied, load shifted automatically to change inclination, propellers shifted thru 180°, engine shifted with propeller, tubular frame of machine used as a condenser.

Fig. 1.



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98. PNEUMATICS,
Aerial Navigation.

244

28

N° 10,620 A.D. 1897

DUPLICATE

Date of Application, 28th Apr., 1897

Complete Specification Left, 28th Feb., 1898—Accepted, 2nd Apr., 1898

PROVISIONAL SPECIFICATION.

Improvements in Aerial or Flying Machines.

I, Hiram Stevens Maxim, of 18, Queen's Gate Place, in the County of Middlesex, Mechanical Engineer, do hereby declare the nature of this invention to be as follows:—

According to my invention I prefer to construct the framing of my aerial or flying machine of diamond shape in plan; that is to say its length is much greater than its width. The said framing is supported on the ground by a pair of strong main wheels situated one at each side thereof and by wheels of a lighter construction situated one at each end thereof. These last mentioned wheels are so arranged that only one of them rests on the ground at a time and they are preferably provided with adjustable means whereby their distance from the ground can be regulated so that the inclination of the framing or machine when on the ground can be varied to cause it to be tilted more or less about the axis of the aforesaid main wheels. When the machine is at rest it is thus supported on three wheels. The weight of the machine will be as much as possible distributed on the said main wheels, and the end wheels will be so arranged that by raising the depressed end of the machine, both wheels will be clear of the ground to permit of the machine being readily turned round or its direction altered. The said main wheels may with advantage be provided with pneumatic tyres.

I propose to lift and drive my aerial machine by means of wings, screws or aeroplanes mounted on upright shafts inclined a few degrees forward from the vertical. Instead of attempting to elevate the machine in the air by a direct screwlike action as others have sought to do, I prefer to employ a lifting surface or contrivance that partakes of the nature of both a screw and an aeroplane. In order to do this it is necessary that the pitch of the screw-blades or aeroplanes shall be exceedingly slight, and for the purpose of overcoming the difficulty of working aerial screws with slight pitch, and of ensuring their lifting with constant force, I construct the screw-blades or planes in such a manner that their pitch is controlled by means of springs so arranged that no blade will be capable of exerting more than a predetermined amount of lifting force. For this purpose the forward edges of the said blades are practically rigid while their rearward edges are more or less flexible and connected to suitable supports, by stays and the aforesaid springs.

By this construction should the blades experience a sudden upward strain as sometimes happens owing to a cross wind or other cause the liability of the said blade-stays to snap will be avoided by their elasticity. Moreover when such strains arise, the flexibility of the blades and their stays will permit a difference in the pitch of the blades to take place and their lifting force will consequently remain practically constant. In other words the greater the lifting effort exerted by the air on the blades the more will the rearward or flexible edges of the blades be raised against the action of the springs, so that if the effort be sufficiently powerful the blades may assume such a position as to have no pitch at all.

[*Price 8d.*]

In order to raise the machine from the ground I rely upon two motions, *viz*:—the rotation of the screws and the travel of the machine over smooth ground, or down a hill, or along a railway track. The latter motion, (the travel of the machine along the ground) is particularly desirable because it has been found that revolving aerial screw planes have little lifting power unless they are constantly meeting or acting upon fresh air (*i.e.* air that has not been disturbed), therefore it is necessary that flying machines should advance rapidly over the ground before they can rise.

By mounting screw blades on inclined shafts so that they revolve as above stated, their planes of rotation are not horizontal, and the inclination of their surfaces relatively to the horizontal is greater as the blades, in their rotation, pass upward and backward than when they pass downward and forward; thus I am able, without the use of articulated joints, to very closely approximate the motion of a bird's wings. The pitch of the said blades and the inclination of their shafts may be so arranged that the blades will be approximately horizontal in their forward movement so that they will not tend to retard the motion of the machine.

The blades are preferably made of light pine wood strengthened by transverse strips or pieces and strong linen glued to their surfaces. I prefer to so construct the blades that they will possess the necessary strength to resist the tendency of the parts to separate under the action of centrifugal force. The blades may however be made in the form of a steel or other framework covered with fabric.

The spring controlled wire-stays for retaining the flexible edges of the blades may each be separately connected to a suitable support on the screw shaft or all the wires may be attached together and be connected to a ring or other support carried by the said screw shaft. In some cases it may be necessary to provide means whereby the tension of the springs may be increased or diminished during the working of the machine, so that if, for instance, one side of the machine have a tendency to lift before the other, it will then be possible to increase the tension of the springs on one side and so bring the machine to an even keel. I prefer however to keep the machine on an even keel by automatically acting on the engines employed for driving the screw blades. For this purpose I may use a weight or pendulum which in the event of one side of the machine rising higher than the other will change its position and bring into operation suitable mechanism for diminishing the lifting effect of the blades on the higher side of the machine and increasing that of the blades on the lower side; such alteration in the lifting effect of the blades being obtained either by throttling the air or diminishing the amount of oil or gas supplied to the engines if they be worked by oil or gas; or if they be worked by steam then the steam may be throttled.

The steering of the machine may also be accomplished by the aforesaid screws, by running one of them faster than the other, or by causing the pitch of one of them to be varied with respect to the other. The machine can thus be caused to turn towards the side which is opposite to the screw that is being operated. Or I may effect the steering by means of steering screws. I prefer however to steer by other means, such as a rudder.

In some cases I may employ, say at the front and rear ends of the machine, auxiliary screws which are so arranged that they may be caused either to lift or to propel the machine through the air. I prefer to mount each auxiliary screw so that its shaft may be turned through an angle of about 180° (while the blades are acting) so that the said screw will lift the machine or push it forward as may be required. I also provide means whereby the load, consisting of the passengers or the oil or other fuel, is mounted on the machine in such a manner that it may be shifted at will either forward or backward to vary the inclination of the machine. If preferred the shifting of the said load may be effected automatically and thus compensate for irregularities and keep the plane of the machine at a predetermined level.

The inclination of the machine previous to starting may be modified to some extent by adjusting the aforesaid end wheels of the machine.

I prefer to use two series of engines for driving the screw shafts, each series being advantageously composed of four working cylinders. I may arrange the cranks at angles of 180° and connect two cylinders to each crank, the said engines if worked by oil or gas, acting on the Otto cycle. In this manner I obtain a working stroke at each half revolution of the shaft, and as the cylinders are near together and the pistons all alike, one balances the other, so that the working of the engines does not detrimentally affect the balance of the flying machine.

It is to be remarked that oil engines, that is to say engines in which the vapours of petroleum are used in place of coal gas, do not work so well or develop so much power as when ordinary coal gas is employed. But I find that if acetylene gases be used in place of petroleum oil vapour, the power of the engines may be greatly augmented and the certainty of their action increased, owing principally to the fact that the range of explosive mixtures composed of acetylene gas and air is much greater than that of mixtures composed of oil vapours or gas and air. I therefore prefer to use acetylene gas for driving my engines; and in order to render the use of such gas safe and to reduce the pressure to which it must be subjected to keep it in a liquid condition within the reservoirs, I prefer to mix therewith a substance such as acetone or acetic ether or some of the other carbonaceous liquids.

I prefer to use electrical ignition for firing the working charges admitted to the oil or gas engines, so that in the event of a collision or other accident occurring, there would be little liability of setting on fire the petroleum oil or the gas contained in the reservoirs.

The auxiliary screws at each end of the machine may either be driven from a single engine or each of them may be provided with its own engine. In the latter case each engine may be arranged to be tilted or shifted together with the screw it drives.

The framing of the machine may consist of steel tubes and steel cross-stays. The two upright screw shafts are preferably located near the middle of the framing and are held in position by a strong strut extending from one shaft to the other and properly stayed with wires. In order to cool the water used for jacketing the working cylinders of the oil or gas engines, or to condense the exhaust steam, if steam engines be employed, the water or the steam can be caused to circulate within the tubular framing so as to be cooled by the surrounding air.

Dated this 28th day of April 1897.

HASELTINE, LAKE & Co.,
45, Southampton Buildings, London, W.C., Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements in Aerial or Flying Machines.

I, Hiram Stevens Maxim, of 18, Queen's Gate Place, in the County of Middlesex, Chevalier of the Legion of Honour, Civil and Mechanical Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in aerial or flying machines.

According to my invention I propose to elevate and drive my aerial machine by means of revolving wings, screw blades or aeroplanes mounted on shafts inclined a few degrees forward from the vertical, and instead of attempting to elevate the machine solely by a direct screwlike action as others have sought to do, I prefer to employ a lifting surface or contrivance that partakes of the nature of both a screw and an aeroplane. In order to do this it is desirable that the pitch of the screw-blades or aeroplanes shall be exceedingly slight, and for the purpose of overcoming the difficulty of working aerial screws with slight pitch, and of ensuring their lifting with constant force, I construct the screw-blades or aeroplanes in such a manner that their pitch is controlled by means of springs, so arranged that none of the blades will be capable of exerting more than a predetermined amount of lifting force. For this purpose the leading or forward edges of the said blades are practically rigid, while their rearward edges are more or less flexible and connected to suitable supports by stays and the aforesaid springs.

In some cases it will be found necessary to provide means whereby the tension of the springs can be increased or diminished during the working of the machine, so that if, for instance, one side of the machine should have a tendency to lift before the other, it will then be possible to increase the tension of the springs on the other side and so bring the machine to an even keel.

I prefer however to keep the machine on an even keel by automatically acting on the engines employed for driving the screw-blades. For this purpose I may use a gravity controlled weight or pendulum which, in the event of one side of the machine rising higher than the other, will change its position and bring into operation suitable mechanism for diminishing the lifting effect of the blades on the higher side of the machine and increasing that of the blades on the lower side; such alteration in the lifting effect of the blades being obtained in an oil or gas engine either by throttling the air or diminishing the amount of oil or gas supplied thereto; or in a steam engine by throttling the steam.

In some cases I employ, say at the front and rear ends of the machine, auxiliary screws which are so arranged that they may be caused either to assist in lifting the machine or in propelling it.

I also provide means whereby the load carried by the machine is capable of being shifted at will either forward or backward to vary the inclination of the machine. If preferred the shifting of the load may be effected automatically and thus compensate for irregularities and keep the plane of the machine at a predetermined level.

The steering of the machine may be accomplished by the aforesaid main screws or aeroplanes, by revolving one of them faster than the other, or by causing the pitch of one of them to be varied with respect to the other. Or I may employ steering screws, or a rudder, or other appropriate means for steering.

In order that my said invention may be clearly understood and readily carried into effect I will proceed to describe the same more fully with reference to the accompanying drawings in which:—

Figure 1 is a side elevation;

Figure 2 a plan;

Figure 3 a front elevation; and

Figure 4 a transverse section

Figure 5 is a detail sectional view showing on a larger scale one of the adjustable end wheels with which the machine is provided.

Figure 6 is a longitudinal section of a portion of the machine showing the movable platform and means for shifting it.

Figure 7 is an enlarged view showing one of the screw-blades or aeroplanes and the engines for driving the same.

Figures 8, 9 and 10 show in elevation, plan and end view respectively the means whereby the position of the auxiliary screws or propellers, together with the engines driving them, may be varied.

In all these figures like letters of reference indicate similar parts.

A is the framing of the machine which is preferably constructed of steel or other metal tubes suitably connected together and made rigid by means of appropriate stays or struts. The said machine is supported on the ground by a pair of centrally disposed main wheels B, and by wheels B^1 B^2 located one at each end of the machine. These last mentioned wheels are so constructed and arranged that only one of them rests on the ground at any time. For this purpose each wheel is carried by a pivoted arm b (see Figure 5) whose free end b^1 is connected to a screw threaded spindle b^2 passing through a nut b^3 that is mounted in a standard b^4 so as to revolve therein without shifting longitudinally. The said nut is provided with a hand wheel b^5 for revolving it when it is desired to cause the aforesaid arm b to be shifted and the wheel carried thereby to be raised or lowered. By thus adjusting the said end wheels the inclination of the machine when resting on the ground can be varied longitudinally and the machine be tilted more or less about the axis of the main wheels B so as to lie with one of its ends higher than the other. In Figure 1 the said end wheels have been so adjusted that the wheel B^1 is out of contact with the ground while the wheel B^2 rests thereon and assists in supporting the machine. The weight of the machine is so distributed as to be practically balanced on the said main wheels B so that by raising the depressed end of the machine until both of the end wheels are out of contact with the ground, the machine can be readily turned to the left or the right to alter its direction.

C C are the inclined shafts carrying near their upper ends the screw-blades or aeroplanes C^1. These shafts are located one at each side of the machine and are inclined a few degrees forward from the vertical, each shaft being provided with four screw-blades or planes C^1 the pitch of which is exceedingly slight. The shape of these blades in cross section is such that the leading edge c thereof is practically rigid while the rearward edge c^1 is flexible (see Figure 7). The leading edge of each blade is connected by stays c^2 to a fixed collar C^2 firmly attached to the shaft C. The rearward edge of each of the said blades is connected by means of stays c^3 to a loose collar C^3 mounted on the shaft C. This loose collar is coupled by means of springs C^4 to another loose collar C^5 mounted on the shaft C. This last mentioned collar is firmly held in position on the shaft by means of a lever C^6 so that, while it is free to revolve with the shaft, it cannot shift thereon longitudinally except by adjusting the position of the said lever by a hand wheel C^7. This hand wheel has a screw threaded nut C^8 that engages with a correspondingly screw threaded spindle C^9 coupled to the lever C^6 by a pivot pin C^{10}. By means of this device the tension of the springs can be diminished or increased according as the collar C^5 is shifted upward or downward on the shaft C toward or away from the collar C^3.

The flexibility of the rearward edges of the blades and the provision of the spring-stays c^3 permits the pitch of the said blades to vary in accordance with the lifting force they experience; that is to say should the blades be subjected to a sudden upward stress as sometimes happens owing to a cross wind or other cause, the flexible edges of the blades will be permitted to bend upwardly without snapping the stays c^3. Moreover when such stresses arise the pitch of the blades will be diminished, with the result that their lifting power will remain practically constant; in other words the greater the lifting effort exerted by the air on the blades the more will the flexible edges of the blades be raised against the resistance of the springs, so that if the effort be sufficiently powerful the blades may assume such a shape and position that they will have no pitch at all.

By adjusting the position of the collars C^5 on their shafts I can vary the lifting power of the blades on either side of the machine, so that if one side should have a tendency to lift before the other, the machine can be brought to an even keel by diminishing the tension of the springs on that side of the machine which is exerting the greater amount of lifting power; the pitch of the blades C^1 on that side is thus lessened. Obviously a similar effect may be obtained by increasing the tension of the springs on the side of the machine that is exerting the smaller amount of lifting power.

The machine can be kept on an even keel automatically by means of a governor of the kind illustrated in Figure 4, in which I have shown a movable weight or pendulum E pivotally connected at e to a fixed point located midway between the pair of main wheels B and coupled by means of rods e^1 and levers e^2 to the valves *d* of the engines used for driving the blades C^1. In the event of one side of the machine rising higher than the other, the pendulum E will still remain vertical by the action of gravity with the result that the aforesaid rods e^1 and the levers e^2 will be actuated to cause the valves *d* to admit less motive fluid to the engines on the side of the machine which is tending to rise and more motive fluid to the engines on the opposite side. The speed of revolution of the screw blades on the rising side of the machine will thereby be reduced while that of the blades on the other side of the machine will be increased. The machine will therefore be brought to an even keel and in assuming this position will restore the valves *d* to their normal condition. Or the said valves may be so arranged that only one of them at a time is acted upon. I may provide the pendulum E with a hand lever E^1 so that if necessary the valves of the engines can be controlled by hand.

The steering of the machine may also be accomplished by causing the screw-blades C^1 to revolve at different speeds relatively to each other and this variation in speed can be effected by the operation of the aforesaid hand lever E^1; the direction of the course of the machine will thus be altered from left to right or *vice versa*, according as the speed of the blades on one or other side of the machine is varied.

The blades being mounted on inclined shafts as above set forth and caused to revolve in opposite directions as indicated by the arrows in Figure 2, their planes of rotation are not horizontal and therefore the inclination of their surfaces relatively to the horizontal varies throughout their revolution, so that without the use of articulated joints I am able to fairly imitate the motion of the wings of a bird. The pitch of the said blades and the inclination of their shafts are so arranged that the said blades will be approximately horizontal in their forward movement and therefore will not retard the advance of the machine in a horizontal direction through the air.

The blades are preferably made of light pine-wood strengthened by transverse strips or pieces covered with strong fabric such as silk or linen. The blades may however be made of a steel framework covered with strong fabric.

I prefer to use two series of engines for driving the aforesaid shafts and their blades, one series being provided for each shaft. Each series has preferably two pairs of cylinders D D, D^1 D^1 (see Figure 7) arranged horizontally one above the other with their connecting rods coupled to cranks C^{11} formed near the lower end of the shaft C and disposed at angles of 180°.

If oil or gas engines are employed I prefer that they should work according to the series of operations known as the "Otto cycle." In this manner and by the above described arrangement of the cylinders I obtain a working stroke at each half revolution of the shaft and as the cylinders are near together and their pistons are all alike, one balances the other during working and consequently the equilibrium of the machine is not materially affected by the working of the engines.

I would here remark that oil engines, that is to say, engines in which the vapour of petroleum is used instead of coal gas do not develope so much power as those in which ordinary coal gas is employed; but I find that if acetylene gas be used in place of the petroleum vapour the power of the engines may be greatly augmented and the certainty of the ignition of their explosive charges be increased. I therefore prefer to use acetylene gas for driving my engines and in order to avoid the necessity of carrying gas compressed in reservoirs under great pressure which renders its use unsafe, I propose, in order to reduce the pressure to which it has to be subjected to keep it in a liquid condition within the reservoirs, to mix therewith a substance such as acetone, or acetic ether, or some of the other carbonaceous liquids. The proportions in which these substances are mixed together may be considerably varied but I find that when the carbonaceous substance is used in the proportion of about one volume to fifty volumes of the acetylene gas, satisfactory results are obtained. D^2 D^2 (Figure 1) are the reservoirs for containing the acetylene gas and carbonaceous substance. I prefer to use electrical ignition for my engines so as to avoid the use of a naked flame which would be liable to cause ignition of the gas if the machine were to strike the ground in its descent with sufficient violence to break the reservoirs and allow the gas to escape and reach the flame.

For the purpose of shifting the load carried by the machine I may employ a movable platform F (see Figure 6) having at each end thereof an eye *f* from which a cord or wire rope f^1 is led to a centrally disposed drum f^2 around which the said cords are wound. This drum is mounted in a suitable standard or support within which it is capable of being revolved by a hand wheel f^3. The revolution of this hand wheel causes a pull to be exerted upon one or other of the said cords according to the direction of revolution, with the result that the platform F is shifted longitudinally in a forward or a rearward direction. The underside of the platform is furnished with slides f^4 that work upon horizontal members A of the framing of the machine and act as guides. Some of the slides are provided with a hand wheel f^5 so that when the platform has been shifted to the required position, these slides can be caused to tightly grip the members A and thereby firmly retain the platform in position.

In order to raise the machine from the ground I rely upon two motions, *viz*:—the rotation of the screw-blades C^1 and the travel of the machine over level ground, or down a hill, along a railway track or other good surface. This travel of the machine is particularly desirable because it has been found that revolving aerial screw-blades have little lifting power unless they are constantly meeting with or acting upon air that has not been already disturbed by their revolution.

At the front and rear ends of the machine I provide auxiliary screws G G each of which is carried by a shaft *g*, (see Figures 8, 9 and 10) which is supported in bearings g^1 g^1 forming part of a movable frame g^2. This frame is provided with trunnions g^3 mounted in bearings g^4 forming part of sockets g^5 connected to the vertical members of the main framing A of the machine. The said frame g^2 is furnished with toothed segments g^6 which are adapted to work in guides g^7 carried by sockets g^8 fixed to the aforesaid members of the framing A. One of these guides is furnished with a pinch block g^9 which can be caused to grip one of the segments g^6 by a movement of the handle g^{10} and thereby retain the frame in the required position. The aforesaid trunnions g^3 constitute pivots about which the frame can be turned through an angle of about 180° in order to bring the auxiliary screws into a position for assisting in lifting the machine or propelling it through the air. This turning of the said frame is effected by means of a crank handle g^{11} mounted on a transverse spindle g^{12} carrying toothed pinions g^{13} that gear with the aforesaid toothed segments g^6. The aforesaid frame is also provided with an engine G^1 which may be of any appropriate construction and which is rigidly connected to the said frame by means of arms G^2 fixed to the longitudinal members of the said frame. The steam or other motive fluid by which the aforesaid engines are worked may be advantageously supplied through a pipe g^{14} leading to one of the hollow trunnions g^3 of the frame, so that the movement of the aforesaid frame will not impede the free flow of the motive fluid to the engine. The position of the said auxiliary screws is thus capable of being adjusted while they are revolving.

In order to cool the water used for jacketing the working cylinders of the oil or gas engines, or to condense the exhaust steam (if steam engines be employed), the water or the exhaust steam can be caused to circulate through the tubular framing of the machine so as to be cooled by the surrounding air.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A flying machine provided with screw blades or revolving aeroplanes whose pitch is controlled by springs for the purposes specified.

2. Screw blades or aeroplanes constructed with one edge rigid and the other

edge flexible the said flexible edge being controlled by spring stays substantially as and for the purpose specified.

3. A flying machine provided with a pair of shafts inclined forward from the vertical and carrying flexible screw blades or aeroplanes having a slight and variable pitch and arranged to revolve in opposite directions as and for the purpose specified.

4. A flying machine provided with propelling blades substantially as described which in starting the machine first drive it forward and then raise it.

5. The combination with the springs for controlling the pitch of the propeller blades of means whereby the tension of such springs can be varied substantially as described and for the purposes specified.

6. The gravity controlled weight or pendulum for acting on the inlet valves of the engines used for driving the main propeller blades, substantially as described and for the purposes specified.

7. The auxiliary screw blades mounted in frames that are capable of being shifted angularly for the purposes specified.

8. The movable platform for enabling the load carried by the flying machine to be shifted substantially as described and for the purpose specified.

9. In my improved flying machine the adjustable end wheels arranged in combination with the main wheels for enabling the machine to be tilted in a vertical plane while on the ground substantially as described and for the purposes specified.

10. In a flying machine the employment of a mixture of acetone or acetic ether or other carbonaceous liquid and acetylene gas for driving the engines, for the purposes specified.

11. A flying machine having its parts constructed arranged, and adapted to operate substantially as described with reference to the acompanying drawings.

Dated this 28th day of February 1898.

HASELTINE, LAKE & Co.,
45, Southampton Buildings, London, W.C., Agents for the Applicant.

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